MINES AND MINERALS DEPOSITS (EXCEPT FUELS)
GALLATIN COUNTY, MONT.

BY GLENN C. REED

* * * * * * * * * **Information Circular 7607**

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INTRODUCTION

This report is one of a series describing mineral investigations within the Missouri River Basin in Montana. The primary purposed of these investigations is to provide information to agencies of the Department of the Interior and others concerned with the planning of Federal power developments in the basin.

This report is limited in scope to consideration of mineral deposits of presumed inventory value within Gallatin County, Mont. The field investigations were made during the fall of 1948.

Mining of metallic mineral deposits to the present time has played only a secondary part in the county's economy. Although small amounts of precious and base metals have been won, the mining industry has been restricted principally to the exploitation of nonmetallic deposits.

Pertient factual information concerning the few long-inactive metallic mineral deposits is meager; most underground workings are inaccessible. Because of these conditions, considerable dependence has been placed on information obtained from Federal and State publications and company records.

ACKNOWLEDGMENTS

Compilation of part of the data contained herein was materially assisted by the courteous cooperation of mine owners, company officials, and operators. Essential information concerning their respective company activities as related to the mineral industry within the county was provided by officials of the Montana Power Co., the Northern Pacific Railroad, and the Chicago, Milwaukee, St. Paul, & Pacific Railroad.

Statistical information was supplied by the Economics and Statistics Service, Bureau of Mines, Salt Lake City, Utah. Climatological data were supplied by the U. S. Weather Bureau, Helena, Mont.

Valuable information was obtained from reports and published and unpublished manuscripts of the U. S. Bureau of Mines, the U. S. Geological Survey, and the Montana Bureau of Mines and Geology. Information sources are indicated in the text by numbers designating items in the list of references.

LOCATION AND ACCESSIBILITY

Gallatin County (population 18,269) is in south-central Montana between meridians 110°48' and 111°48' west and parallels 44°29' and 46°11' north. Its borders enclose an area of 2,493 square miles.

The highway and railroad networks serving this region are shown in figure 1. Bozeman, Mont. (population 8,665), the county seat and principal supply point, is 96 miles east of Butte, Mont., and 26 miles west of Livingston, Mont., by U. S. Highway 10.

Transcontinental lines of the Northern Pacific and the Chicago, Milwaukee, St. Paul, & Pacific Railroads serve the northern part of the county. West Yellowstone, a tourist center at the county's south extremity and one of the entrances to Yellowstone National Park, is the terminus of a Union Pacific Railroad spur extending northward from Pocatello, Idaho.

CLIMATE

The seasonal temperature extremes common to the northern Rocky Mountain province are balanced in Gallatin County by a prevailing low humidity and usually abundant sunshine. At the lower altitudes, an average growing season of 93 days has encouraged the development of a diversified agriculture.

Climatological records indicate an average annual precipitation of about 20 inches. However, the mountain areas actually receive greater precipitation than indicated by records collected at valley observation points. Snow depths commonly range from 5 to 13 feet and average about 7 feet throughout the elevated areas.

Climatological data recorded at several stations in Gallatin County, Mont., are given in tables 1 and 2. These statistics were provided by the U. S. Weather Bureau, Helena, Mont.

TABLE 1. - Average monthly and annual precipitation1/ and snowfall, in inches, at following U. S. Weather Bureau Stations in Gallatin County, Mont.

Station........	Boxeman (Agricultural College)		Hebgen Dam (Grayling)		Three Forks	
Elevation, feet.	4,856		6,550		4,070	
	Precipitation1/	Snowfall	Precipitation1/	Snowfall	Precipitation1/	Snowfall
Length of record, years.	72	30	45	25	21	14
January.........	0.87	10.8	2.63	38.7	0.41	3.5
February........	.81	8.5	2.06	25.7	.40	4.6
March...........	1.27	13.1	2.01	20.8	.42	2.9
April...........	1.69	6.3	1.61	10.6	1.03	2.7
May.............	3.06	1.9	2.18	3.4	1.73	.6
June............	2.89	.0	2.33	.4	2.16	.0
July............	1.28	.0	1.79	.0	1.40	.0
August..........	1.09	.1	1.31	T	.96	.0
September.......	1.69	.9	1.63	1.0	1.34	.4
October.........	1.42	4.8	1.79	7.0	.92	2.4
November........	1.00	11.2	1.91	16.4	.63	3.6
December........	.98	10.8	2.17	27.8	.55	2.8
Annual average	18.03	68.4	23.42	151.8	11.95	23.5

1/ Includes snowfall converted to water

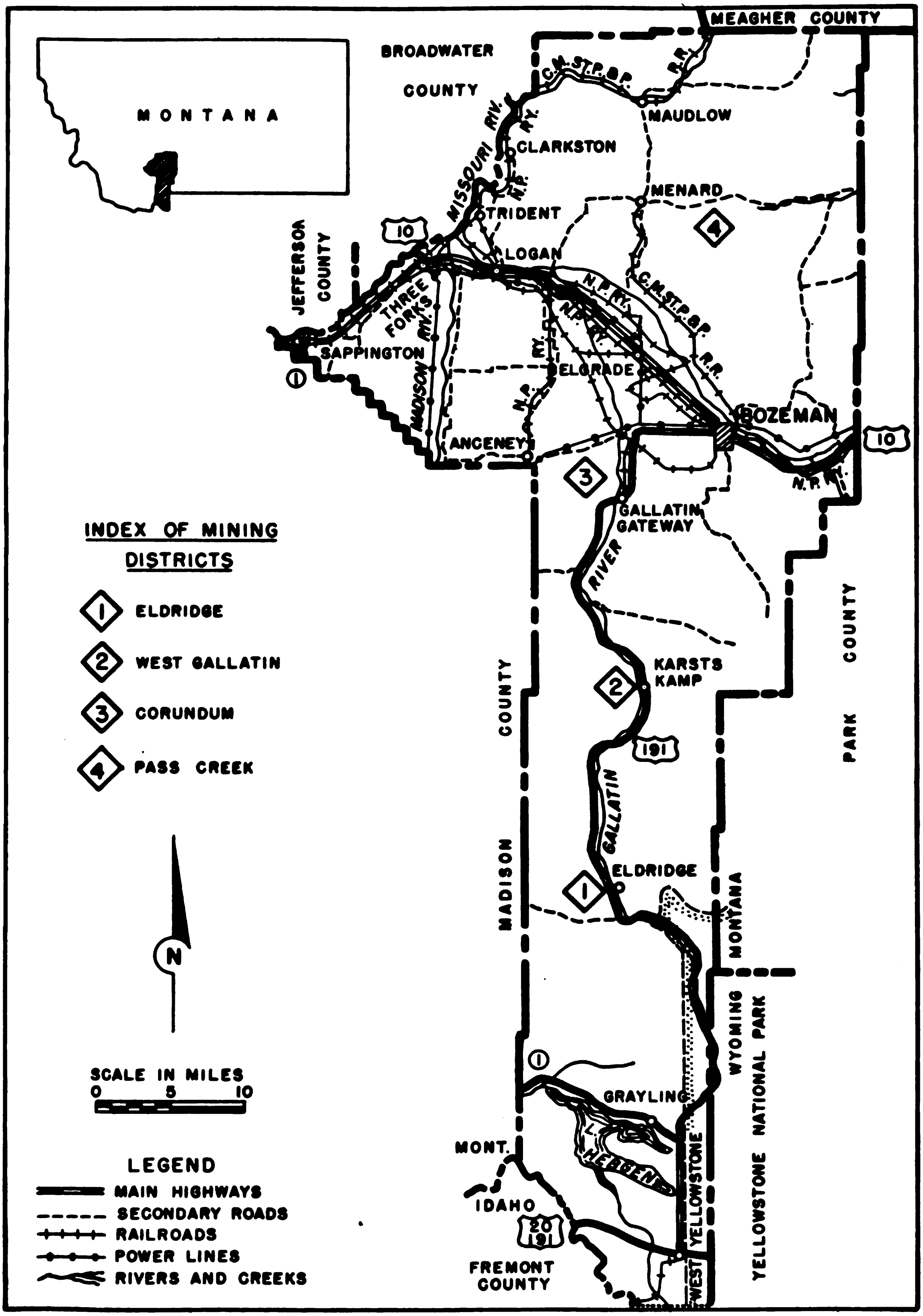

Figure 1. - Index map, Gallatin County, Mont.

TABLE 2. - Average temperature data, °F., at following U. S. Weather Bureau Stations in Gallatin County, Mont.

Station.........	Bozeman (Agricultural College)	Hebgen Dam (Grayling)	Three Forks
Elevation, feet.	4,856	6,550	4,070
Length of record, years.	36	25	16
Annual average..	41.5	35.2	43.1
Mean maximum:			
January.......	29.6	22.1	32.8
July..........	78.6	77.0	84.3
Annual........	52.8	49.0	57.1
Mean minimum:			
January.......	11.2	4.6	9.8
July..........	49.8	40.8	49.5
Annual........	30.2	21.5	29.1
Highest:			
January.......	65.0	45.0	64.0
July..........	104.0	98.0	101.0
Annual........	112.0	98.0	101.0
Lowest:			
January.......	-53.0	-46.0	-49.0
July..........	29.0	25.0	31.0
Annual........	-53.0	-60.0	-49.0
Latest date 32° or lower in spring........	May 8 to July 14	June 9 to July 15	July 8
Earliest date 32 or lower in fall..........	August 9 to October 14	July 16 to September 18	August 19

PHYSICAL FEATURES

Altitudes in Gallatin County range from about 4,000 feet in the Gallatin Valley to more than 10,000 feet above sea level in the Gallatin and Madison Ranges. The north-trending Gallatin Range, marking much of the county's east boundary, curves gently northwest into the Bridger Mountains. Although the principal mass of the Madison Range is beyond the county's west boundary, its eastern flanks and foothills occupy a large part of the county area.

The Bridger and Gallatin Ranges are separated by a low pass that marks the east limit of the broad Gallatin Valley, whereas the Madison and Gallatin Ranges are sharply divided by the north-flowing Gallatin River.

The county is drained to the north by the Gallatin and Madison Rivers and a network of branching tributaries. These streams unite with the Jefferson River at Three Forks, Mont., and there form the Missouri River. The numerous tributary streams, fed principally by melting snows, provide an abundant and dependable water supply.

The Gallatin Valley and the rolling foothills flanking the Madison and the Bridger Ranges are largely unforested. Cottonwood, aspen, and other deciduous varieties usually mark the courses of the rivers and perennial streams. The northern slopes at the higher altitudes, however, generally are thickly forested with fir, lodgepole pine, and cedar. Virtually all of the timbered lands lie within the National Forest boundaries......

POWER

Electric energy for industrial and domestic consumption is supplied to the northern third of Gallatin County by a transmission loop and seven substations owned by the Montana Power Co. This loop, originating at the Madison Hydro-electric station in Madison County, has a capacity of 3,000 to 5,000 kilowatts at an operating level of 50,000 volts. Substations at Three Forks, Trident, Logan, Manhattan, Belgrade, Bozeman, and Hot Springs are included in the system.

Provision for a marked increase in the consumption of electric energy at the Trident plant of the Ideal Cement Co. is being made by the construction of a second circuit linked to the Montana Power Co. Helena-Great Falls distribution network. At the present time, utilization of electric energy by the mineral industry in Gallatin County is limited to that consumed by the Ideal Cement Co.

Charges for industrial energy supplied by the Montana Power Co. throughout the State are given in table 3. This schedule is based upon a sliding scale for actual kilowatt-hours consumption plus a charge based on peak demand.

TABLE 3. - Montana Power Co. power rates - Schedule GS-44

Rate per kw.-hr.	Kilowatt-hours
$0.75	For the first 12 or less
.035	For the next 288
.025	For the next 1,500
.015	For the next 3,200
.009	For the next 15,000
.007	For the next 200 kw. of demand
.005	For all additional kw.-hr.

Plus demand charge:

First 10 kw.	No charge
Next 20 kw.	$0.95 per kw. of demand
All additional kw.	.75 per kw. of demand

RAILROAD FREIGHT RATES

Freight rates quoted October 1948 on ores and concentrates from selected Northern Pacific Railroad shipping points in Gallatin County, Mont., to Montana smelters, per ton in 30-ton minimum carload lots, were as follows:

	Value per ton, not exceeding -					
	$15	$25	$35	$50	$100	Over $100 1/
To A. S. & R. Co. smelter, East Helena, Mont., from:						
Bozeman	$2.38	2.68	3.02	3.74	3.94	--
Anceney	2.38	2.68	3.02	3.74	3.94	--
Logan	2.06	2.32	2.68	3.22	3.38	--
Sappington	2.22	2.51	2.86	3.58	3.74	--
To Washoe sampler, A.C.M. Co., Butte, Mont., from:						
Bozeman	2.38	2.68	3.02	3.74	3.94	--
Anceney	2.38	2.68	3.02	3.74	3.94	--
Logan	2.06	2.32	2.68	3.22	3.38	--
Sappington	2.06	2.32	2.68	3.22	3.38	--
To A.C.M. Co. zinc plant, Great Falls, Mont., from:						
Bozeman	4.76	5.36	6.04	7.48	7.88	--
Anceney	4.76	5.36	6.04	7.48	7.88	--
Logan	4.44	5.00	5.70	6.96	7.32	--
Sappington	4.60	5.19	5.88	7.32	7.68	--

1/ For each $50 a ton (or fraction thereof) increase in value above $100 a ton, add 20 percent to the rates provided herein for ores and concentrates of value of $100 a ton.

Freight rates on ores and concentrates per ton, in minimum 30-ton lots, quoted October 1948, from shipping points in Gallatin County, Mont., to the Washoe sampler, A. C. M. Co., Butte, Mont., via the Chicago, Milwaukee, St. Paul, & Pacific Railroad, were as follows:

From-	Value per ton, not exceeding -					
	$15	$25	$35	$50	$100	Over $100
Bozeman	$2.53	$2.53	$2.82	$3.42	$3.58	$3.86
Gallatin Gateway	2.68	2.68	3.12	3.72	3.86	4.46
Logan	2.23	2.23	2.53	2.98	3.12	3.58
Sappington	2.02	2.23	2.53	2.98	3.12	3.58

HISTORY

Mining has played only a small part in the economic development of Gallatin County. Consequently, the historical record concerning the county's mining operations is particularly barren.

Gold-placer operations apparently were intermittently active during the period 1880-1900 in the Spring Hill district along the Gallatin River, at West Fork, and at Taylor Fork west of Eldridge. Early output from these operations is unknown. According to local residents, the workable gravels were limited in extent and not particularly high in gold content. However, operations continued sporadically at small scale up to 1945. The annual output of gold from these ventures seldom exceeded a few ounces.

Prospecting in the Pass Creek area resulted in the discovery of base-metal deposits prior to 1901. The September Morn lode, evidently the most important of these discoveries, was active for short periods in 1915, 1925, 1936, and 1939-40. Scale of operation at this property is indicated by a recorded aggregate output of less than 100 tons of ore.

The recognition in 1901 of amphibole asbestos at Karst can be considered one of the earliest lode discoveries of significance made in Gallatin County. However, production over the years has been sporadic, principally owing to marketing difficulties.

Corundum-bearing deposits were discovered several miles west of Gallatin Gateway in 1901 and 1902. The aggregate output from these deposits up to 1903 is believed to have amounted to more than 400 tons of corundum concentrates. The deposits were investigated by the Bureau of Mines during the recent war years because of an impending shortage of imported corundum.

Extensive limestone beds at Trident were opened in 1908 by the Ideal Cement Co. to provide raw material for lime and Portland-cement manufacture. This operation has continued without interruption to the present time. An expansion program designed to increase plant output to 3,500 barrels of cement daily is nearing completion.

PRODUCTION

The known production of metallic minerals from Gallatin County is small. Statistics embracing the period 1883-1947 indicate a total output valued at $308,083, about 98 percent of which consists of gold and silver produced prior to 1911. Although lode and placer output are not segregated, it appears that part of the reported gold production originated principally from early placer operations along the Gallatin River and its tributaries.

The recorded output of precious metals assigned to Gallatin County during the period 1883-1896 appears to be inconsistent with the known distribution and magnitude of lode and placer deposits operated in the early days. It is believed, therefore, that much of the early production of these metals actually originated from operations in adjoining Madison County. This discrepancy in statistical data apparently stems from the adjustment of county boundaries sometime after 1889.

Official records indicate that base metal production in Gallatin County has been limited to the years 1915-17, 1925, 1936, 1939, and 1940. During the period 1915-40, about 39,000 pounds of lead and 5,000 pounds of copper were produced. This output originated principally from prospecting ventures on Pass Creek, Elk Creek, and in the vicinity of Deer Park. Information concerning these operations is not available.

Total county metal output, by years, is given for the period 1883-1947 in table 4. This table was compiled from data supplied by the Economics and Statistics Service, Bureau of Mines, Salt Lake City, Utah. It should be noted that the table is expressed in terms of recovered metals and therefore does not indicate the true metal content of the ores mined or shipped.

Table 4. - Mine production of gold, silver, copper, lead, and zinc 1/ in Gallatin County, Mont., 1883-1947, in terms of recovered metals

Year	Producing mines		Ore sold or treated (short tons)	Gold				Silver		Copper		Lead		Total value
				Fine ounces				Fine ounces						
	Lode	Placer		Lode	Placer	Total	Value	Lode & placer	Value	Pounds	Value	Pounds	Value	
1883-1896	2/	2/	----	2/	2/	7,259	$150,041	153,168	$150,988	----	----	----	----	$301,029
1897-1900	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/
1901-1910	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1911	----	1	----	----	21	21	424	1	1	----	----	----	----	425
1912	----	1	----	----	6	6	124	----	----	----	----	----	----	124
1913	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1914	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1915	1	1	8	----	2	2	49	----	----	----	----	8,880	$417	466
1916	1	----	25	----	----	----	----	2	1	1,486	$366	----	----	367
1917	2	----	18	----	----	----	----	3	2	3,627	990	----	----	992
1918	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1919	1	----	100	23	----	23	477	16	18	----	----	----	----	495
1920	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1921	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1922	----	1	----	1	----	1	27	----	----	----	----	----	----	27
1923	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1924	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1925	2	----	44	4	----	4	89	18	12	----	----	4,065	355	456
1926	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1927	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1928	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1929	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1930	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1931	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1932	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1933	----	3	----	----	8	8	156	----	----	----	----	----	----	156
1934	----	1	----	----	37	37	1,305	----	----	----	----	----	----	1,305
1935	----	1	----	----	2	2	77	----	----	----	----	----	----	77
1936	1	2	6	----	4	4	133	----	----	----	----	4,413	203	336
1937	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1938	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1939	2	1	26	1	5	6	210	9	6	58	6	5,830	274	496
1940	2	1	24	1	4	5	175	24	17	----	----	15,800	790	982
1941	----	1	----	----	9	9	315	----	----	----	----	----	----	315
1942	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1943	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1944	----	1	----	----	1	1	35	----	----	----	----	----	----	35
1945	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1946	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1947	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Totals			251	30	99	7,388	$153,637	153,241	$151,045	5,171	$1,362	39,008	$2,039	$308,083

1/ No zinc production reported.
2/ Separation of lode and placer output not available.
3/ Information not available.

GEOLOGY (1,2)

Pre-Beltian rocks, occupying about one-seventh of the total area of Gallatin County, are confined principally to the panhandle region, although several relatively small outcrops lie to the north of Bozeman and in the vicinity of Anceney and Sappington (fig. 2). These rocks, locally known as the Pony series, are complexly folded and contorted schists and gneisses marked by igneous injections of pre-Cambrian and later age.

A sequence of arkosic sandstones and conglomerates, argillites, and siliceous limestones exposed in the northern part of the county has been correlated with the Algonkian Belt series. Beyond the north limits of the county, the formation attains a thickness of 11,000 feet or more. To the south of Bozeman, the beds thin out and are absent between the crystalline gneisses and the Paleozoic strata.

The pre-Cambrian rocks are succeeded by 8,000 feet or more of Paleozoic and Mesozoic strata consisting of quartzites, sandstone, shales, and limestone. These rocks, occupying about one-third of the county's area, crop out principally in the panhandle, at Trident, and east and north of Bozeman.

A series of basic lavas, agglomerates, andesitic sandstones, and shales disposed along the county's northeast and east-central borders comprise the westward extension of the late Cretaceous Livingston formation. These beds apparently thin out to the west, where they do not exceed a thickness of 1,000 feet. However, they attain a maximum thickness approaching 12,000 feet in adjoining areas in Park County.

Tertiary lake beds consisting of stratified sand, gravels, volcanic ash, and claylike material lie above the older rocks in the Gallatin Valley and in the Madison Valley near West Yellowstone (fig. 2).

Igneous-rock types, confined principally to the panhandle region, are represented by small remnant areas of rhyolite and basalt. Intrusive rock types other than dikes and sills injected into the pre-Beltian crystallines are not abundant.

Several northwest-trending thrust faults of considerable magnitude have thrown the Archean crystallines into contact with Paleozoic strata. The most persistent member of this series crosses the Gallatin River at the head of Gallatin Canyon. It apparently is the westward extension of the Gardiner overthrust.

METALLIC MINES AND MINERAL DEPOSITS

Metallic production statistics for Gallatin County covering the period 1901-47 record an output of 251 tons of ore. Although no patent applications for the acquisition of mining lands in the county have been filed, several areas have been prospected sporadically, and a few tons of ore has been produced. All these ventures were short-lived and rarely persisted beyond a single season. The importance of metalliferous lode mining in the county, therefore, is clearly secondary to the exploitation of nonmetallic minerals.

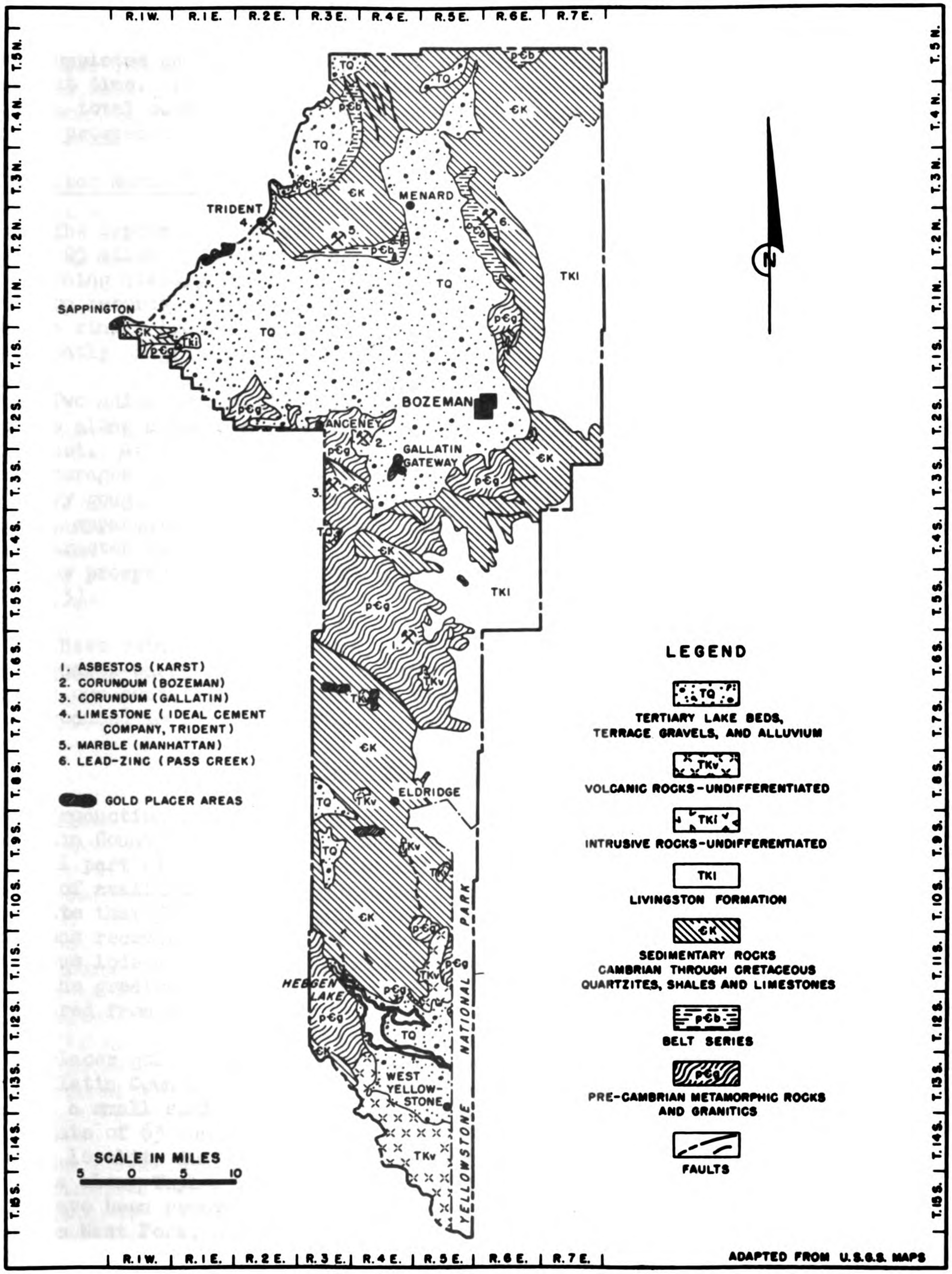

Figure 2. - Generalized geologic map of Gallatin County, Mont.

In 1939 and 1940, a small output of lead ore was taken from the September Morn mine in the Bridger Range. Although a government-financed access road was completed in 1944, the September Morn mine has remained dormant to the present time. Production statistics credit the Deer Park and Elk Creek areas with a total output of 19 tons of crude ore since 1926. Information concerning these prospects is not available.

September Morn (Pass Creek)(Ag-Pb)

The September Morn mine in sec. 6, T. 2 N., R. 6 E., is on Pass Creek about 25 miles by county roads northeast from Belgrade, Mont. Information concerning history and early output of this property is not available. Production records, however, indicate that a small output of lead ore was made from a single lode deposit on Pass Creek in 1939 and 1940. This production apparently originated from the September Morn mine.

Two adits aggregating 750 feet in length partly explore a narrow vein in dacite along a horizontal distance of 300 feet and over a vertical interval of 100 feet. At the upper adit, this vein strikes north, dips 25° to 35° west, and averages about 32 inches in width. Both walls of the vein are marked by a heavy gouge suggesting considerable movement. The lower adit, now inaccessible, apparently also penetrated this vein structure. A second vein, similar in character to that exposed by the adit workings, has been opened by several shallow prospect trenches about 800 feet south and 400 feet above the upper adit (3).

These veins contain galena, scant sphalerite, and traces of molybdenite in a quartz-barite gangue. Production statistics indicate that 37 tons of sorted ore containing 29.3 percent recovered lead and 0.9 ounce silver a ton was produced in 1939 and 1940.

Gold Placer Deposits

Production statistics record an output of 7,388 ounces of gold from Gallatin County during the period 1883-1947. However, the segregation of only a small part of this output between lode and placer sources is possible on the basis of available data. During the period 1901-47, the segregated statistics indicate that 30 ounces of gold was produced by lode mines and 99 ounces of gold was recovered from placer operations. The apparent scarcity of metalliferous lode deposits within Gallatin County gives weight to the assumption that the greater part of the county's recorded gold output probably was recovered from placer operations.

Placer gold is known to have been recovered at five localities (fig. 2) in Gallatin County since 1901. Operations at these deposits were sporadic and on a small scale. Their magnitude is indicated by the fact that an aggregate of 63 ounces of gold constitutes the largest output recorded for a single locality during the period 1901-47. This production was obtained from gravels along Taylor Fork, southwest of Eldridge, Mont. Smaller amounts of gold have been recovered from gravels at the confluence of the Gallatin River and the West Fork, at Gallatin Gateway, and along the Jefferson River near Three Forks, Mont. (4).

NONMETALLIC MINERAL DEPOSITS

The production of nonmetallic (industrial) minerals in Gallatin County greatly overshadows the output of metallic minerals. Nonmetallic mineral production, however, is significant principally because of the exploitation of extensive limestone deposits for cement manufacture at Trident, Mont. Amphibole asbestos is currently mined about 36 miles south of Bozeman, Mont. In the early 1900's and during the recent war years, several hundred tons of corundum concentrates was produced from deposits in the vicinity of Gallatin Gateway, Mont. Deposits of vein calcite, locally termed "onyx marble", have been prospected north of Manhattan, Mont. The salient features of these deposits are presented briefly in the following pages.

Asbestos

Karst (Interstate Products Co.)

The Karst asbestos deposit, sec. 36, T. 5 S., R. 4 E., is on the lower east flank of Wilson Peak at an altitude of 6,900 feet. It is 36 miles south of Bozeman, Mont., via Gallatin Gateway over U. S. Highway 191.

The deposit, reputedly discovered by P. T. Karst in the early 1900's, is believed to have yielded between 1,300 and 1,800 tons of crude ore. About 900 tons of crude ore was produced and shipped to eastern markets during a period of 10 years following the deposit's discovery. In 1935, development by open-cut methods was started by the Karstolite Co. Upon reorganization in 1938, an aerial tram and a small beneficiating plant consisting of a hammer mill and an air classifier were installed. Operations during the period 1938-40 resulted in an output of about 400 tons of crude ore. The property thereupon remained dormant until 1947, when it was acquired by the Interstate Products Co. Since that time a 3-mile access road connecting with U. S. Highway 191 has been built and several hundred tons of crude ore produced.

In 1948, development at the deposit consisted of shallow underground workings aggregating about 200 feet and two small open cuts. These workings explored the deposit along a horizontal distance of 100 feet and over a vertical range of 65 feet. The underground workings were inaccessible. Mining was in progress, however, at one of the open cuts.

Drilling is done by jack hammers powered by a 105-cubic foot, gasoline-driven, portable compressor. Overburden and broken waste are moved by a Diesel bulldozer. Broken ore is hand-shoveled and trammed in small mine cars to a truck-loading bin, from which it is hauled 25 miles to railhead at Gallatin Gateway. The mill plant, now dismantled, formerly was powered by hydroelectric energy generated at a small company-owned installation on Moose Creek just east of the Gallatin River.

Asbestos at the Karst deposit is contained in several relatively small bodies of amphibole peridotite intruded in gneisses and schists correlated with the pre-Beltain Pony series (5). Unaltered pegmatite dikes are conspicuously associated with the asbestos-bearing peridotites.

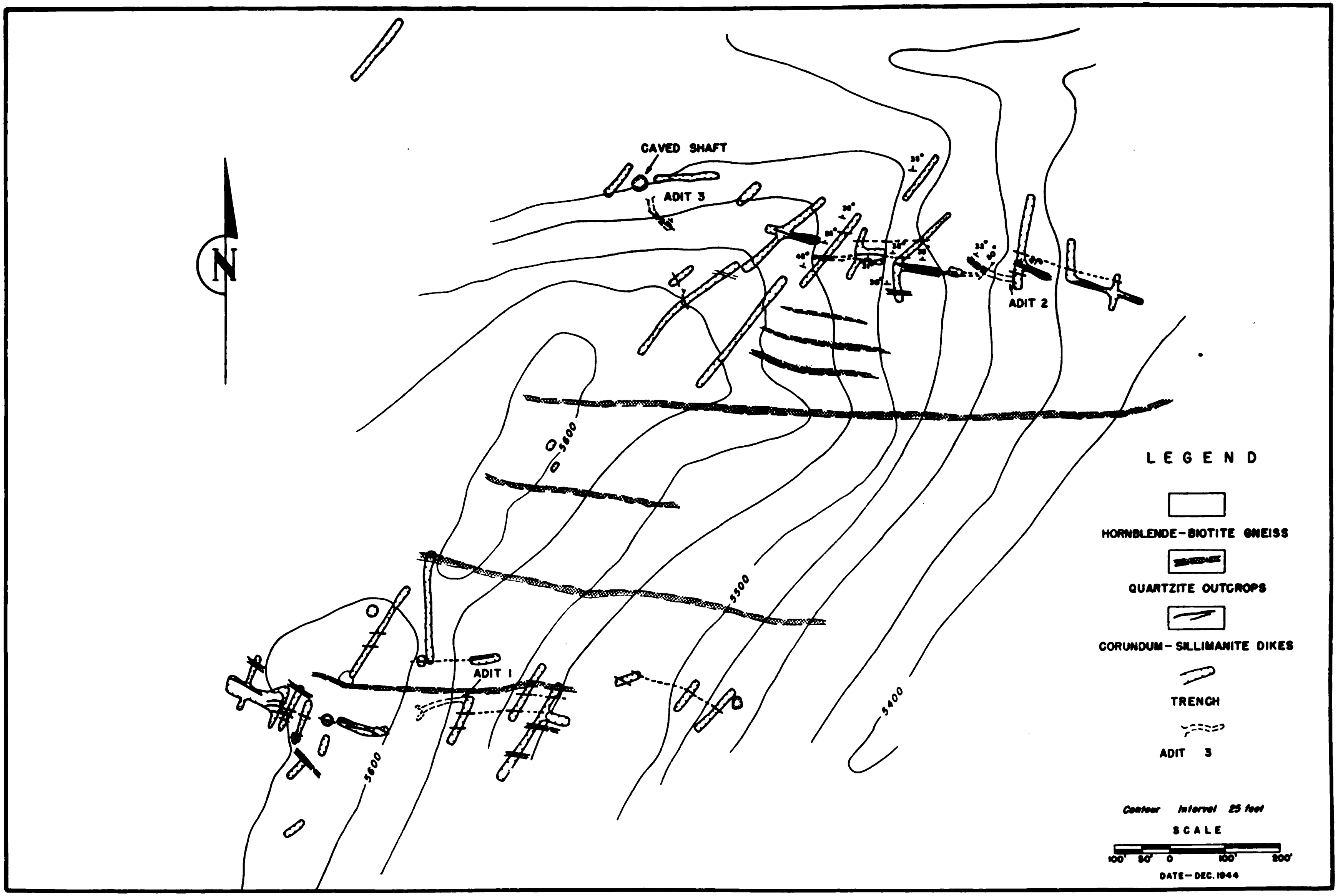

Figure 3. - Base map of trenched area, Bozeman corundum deposit, Gallatin County, Mont.

Alteration of the amphibole proceeding along a nearly vertical fracture system has produced a vein network principally composed of anthophyllite (5). As exposed in the open-cuts, this vein system strikes north to N. 70°W., dips vertically, and ranges from 1 inch to 2 feet in width.

Crystal aggregates up to a foot or more in length are common. They usually are oriented normal to the fracture walls and therefore are termed "cross-fiber." A few of the crystal aggregates, termed "slip-fiber", have their long axis parallel to the vein walls. The recoverable asbestos from these veins is estimated at about 25 percent (5). The following analysis, made at a Northwestern Improvement Co. laboratory, indicates the general composition of asbestos taken from the Karst deposit.

	Percent
SiO_2	56.8
Fe_2O_3..............	9.1
Al_2O_3..............	.9
CaO	3.1
MgO	26.7
Ignition loss.....	2.7

The principal uses of amphibole asbestos are in the manufacture of fireproof wallboard and shingles, heat-insulating coverings, and acid-resistant filtration media.

Corundum

Corundum deposits near the northern end of the Madison Range were prospected and exploited in the early 1900's and during the recent war years. Production from these deposits is estimated to aggregate about 4,500 tons of crude ore containing 5 to 10 percent recoverable corundum.

These deposits are enclosed by Archean metamorphics, chiefly hornblende gneiss, quartzites, and hornblende mica schists. The lineation of these rocks is intricate in detail; in general, they strike between N. 60° E. to east and dip 40° to 70° N. The rocks have been invaded along foliation planes by discontinuous lenses of quartz feldspar pegmatite. Some of these pegmatites contain erratically distributed concentrations of corundum associated with sillimanite, vermiculite, mica, garnet, and rutile.

Although individual pegmatite lenses seldom exceed 200 feet in length, a series of discontinuous lenses may be disposed along the pegmatite-bearing zones for 900 to 5,200 feet. These zones range from 50 to 350 feet in width.

Bozeman

Investigations by the Bureau of Mines at the Bozeman property in 1944 (6) exposed 28 corundum-bearing lenses occupying two parallel, eastward-trending zones. The north zone is about 1,000 feet long and 70 feet wide. The south zone is 900 feet long; its maximum width is 180 feet. These zones are about 900 feet apart (fig. 3).

In general, the exposed lenses are short and narrow. However, assuming continuity between some of the closer exposures, it may be inferred that a few of the lenses may be 100 feet or more long. Although their average width is less than 1 foot, at places the pegmatites have a maximum width of several feet. The vertical continuity of the lenses has not been determined.

Corundum crystals are distributed sporadically throughout a quartz-feldspar matrix, which in some places contains small amounts of sillimanite. Nearly all of the corundum contains inclusions of feldspar and mica. The sillimanite crystals range from microscopic size to an inch or more in length.

Parts of the richer pegmatites contain 8 percent or more corundum; these "high-grade" sections, however, usually are less than 1 foot wide. In the few places where the lenses are wide enough to permit economic extraction, the corundum content is negligible.

Samples cut from the largest lens exposed contained 0.3 percent corundum. On the basis of 55 samples taken by the Bureau of Mines, it is estimated that the average grade of the Bozeman pegmatites as exposed is less than 1 percent corundum (6).

Gallatin (Fuller-Old Corundum)(Montana Corundum)

Investigation of the Gallatin area by the Bureau of Mines during 1943-45 revealed twenty or more corundum-bearing pegmatite dikes and lenses within a zone 5,200 feet long and 200 to 300 feet wide.

The pegmatites are concordant with the enclosing hornblende-mica schists, which strike about N. 68° E. and dip 63° NW. Lenses prospected in depth were found to have a low-angle rake to the west. The largest lens exposed in the area is east of Elk Creek (fig. 4). This body has been explored by mine workings throughout a length of more than 600 feet. Exposures along the western part of the lens range from 1.4 feet to 3 feet in width; its average width is 2 feet.

The corundum-bearing lenses usually are enclosed by a thin envelope of biotite and garnet, which affords a convenient parting for extraction. The enclosing schists, however, are softer than the pegmatite. Consequently, extraction usually is complicated by problems of dilution and ground support.

The corundum crystals characteristically are associated with sillimanite, magnetite, rutile, chlorite, and biotite in a matrix of plagioclase feldspar and quartz. Inclusions of biotite and quartz usually contaminate the corundum. Although the sillimanite content of the matrix approaches 8 percent, it is unsuited for refractory use because of contamination by included iron.

The individual corundum crystals range from microscopic size to 5 inches in length and 1-1/2 inches in diameter. The average corundum content of lenses exposed west of Elk Creek is about 8 percent by weight. Lenses to the east of Elk Creek average about 12.9 percent corundum by weight.

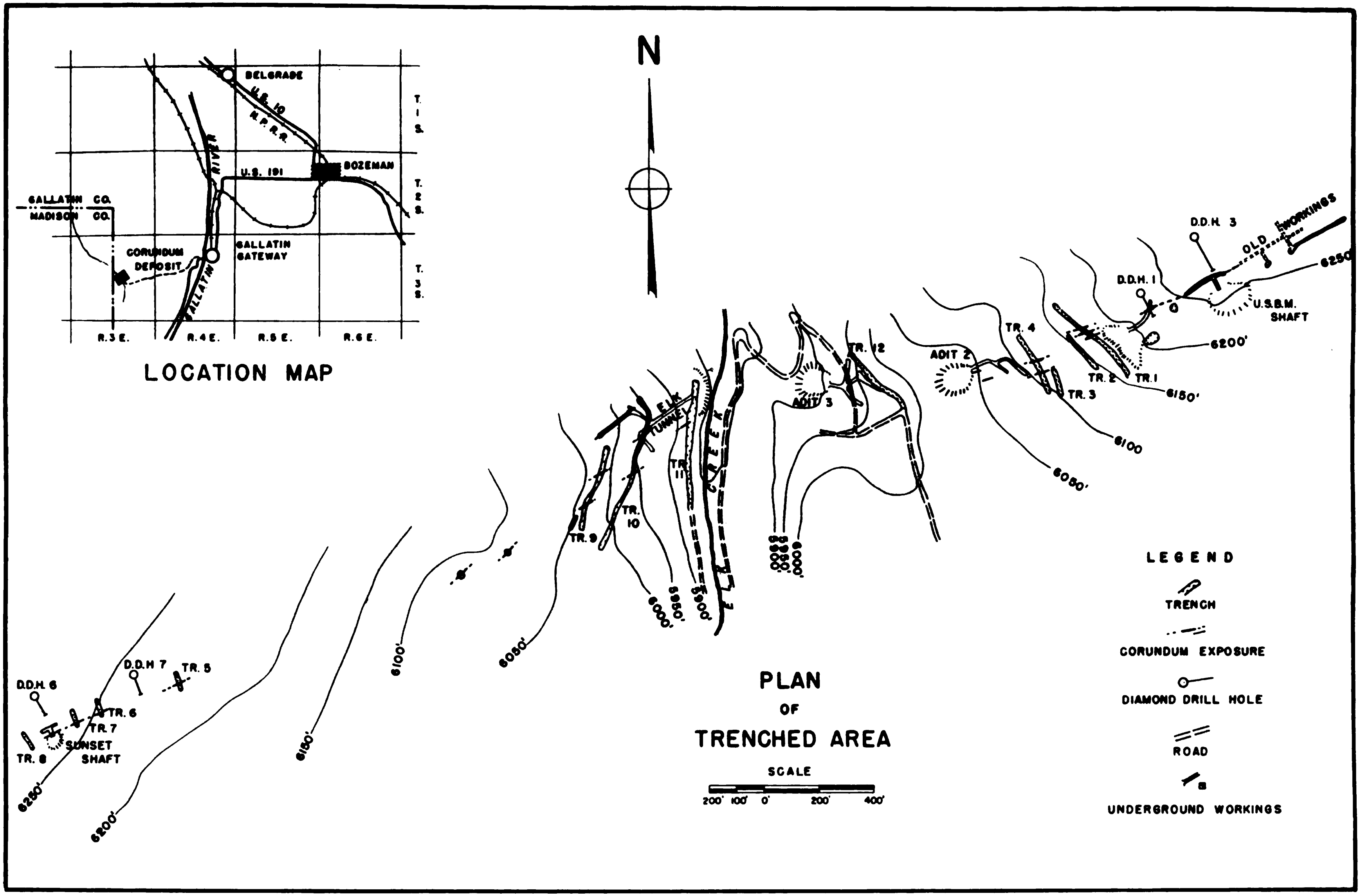

Figure 4. - Gallatin corundum deposit, Gallatin County, Mont.

Benficiation tests undertaken on the Gallatin ores by the Bureau of Mines indicated that 87 percent of the contained corundum could be recovered by combined gravity and magnetic methods in a concentrate containing 77 percent corundum (7).

Limestone

Ideal Cement Co. (Trident)

Extensive exposures of Cambrian, Devonian, and Mississippian limestone occur throughout Gallatin County. At Trident, Mont., in secs. 9 and 10, T. 2 N., R. 2 E., beds in the lower Madison formation of Mississipian age have been exploited as a source of lime for cement manufacture by the Ideal Cement Co. since 1908 (8).

The relatively flat-lying beds at Trident are exposed along bluffs in a narrow gorge cut by the Missouri River. The main quarry is opened by a 75- to 100-foot face, which extends for a distance of 3,000 feet along the bluff on the right bank of the river. A second quarry recently has been opened in higher-grade stone about 2,000 feet southeast from, and stratigraphically above, the main quarry.

Output in 1948 from the main quarry amounted to about 800 tons daily, which contained 74 to 78 percent $CaCO_3$. Output from the second quarry, occasionally used for up-grading and special-purpose mixes, contains about 90 percent $CaCO_3$.

The limestone is mined by standard open-cut methods. Benching rounds drilled by gasoline-powered churn drills are combined with coyote blast holes driven into the toe on grade. The broken rock is loaded by power shovels and trucked less than a mile to the plant head bin.

In addition to limestone, silica rock and, occasionally, magnetite are required in the manufacture of special-type cements. These materials are contract-mined near Radersburg, Mont., and trucked 35 miles to the Trident plant.

The cement-plant output in 1948 was about 2,400 barrels daily. On completion of an expansion program now in progress, plant capacity will be increased to about 3,500 barrels daily. Power consumption in 1948 ranged between 20 and 30 kilowatt hours per barrel.

Marble

Manhattan "Onyx marble" Deposit

Deposits of "onyx marble" have been prospected in sec. 14, T. 2 N., R. 3 E., about 6 miles north from Manhattan, Mont. Output from the deposits has been limited to a small amount of material extracted principally for exhibition and promotional purposes prior to 1932.

A series of prospect pits and small open cuts in Madison limestone have exposed a narrow zone of steep-dipping calcite veins. The principal vein curves in strike from N. 10° W. to N. 30° E., dips vertically, and ranges in width from a few inches to 65 feet. Its indicated length is about one-half mile. The vein zone, however, may be traced along the strike for more than a mile. The enclosing limestone beds strike N. 70°-80° E. and dip 30° NW. According to Mansfield (9), one vertical joint set developed in these limestones conforms with the attitude of the calcite veins.

Near the center of sec. 14, about 25 feet of massive calcite and calcite stringers has been exposed in a small open-cut working. The central part of this zone is sufficiently massive over a width of 10 feet to furnish blocks 2 or 3 feet thick, 5 feet or more long, and 3 or 4 feet wide. The balance of the exposed face consists principally of brecciated and recemented material, in part slabby and thin-bedded.

The "marble" exhibits a variety of patterns. Most common is a wavy, vertically banded structure in which the larger bands, each composed of thinner layers, are about one-half to three-fourths inch wide. The calcite presumably formed in progressively widening fractures, some of which have been filled completely. Others are still open but lined with tiny projecting crystals (9).

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